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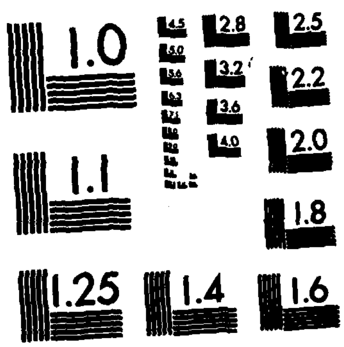

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CHANGES IN THE STATES OF AGGREGATION ON THE ELECTRODES DURING CONDENSED DISCHARGES

by

Vladimir Hermoch, Bohumil Zitka, Karel Sobra

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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Page 486.

CHANGES IN THE STATES OF AGGREGATION ON THE ELECTRODES DURING CONDENSED DISCHARGES.

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In the work were investigated the properties of the condensed discharge from the point of view of energy relationships/ratios. The arc of discharge of approximately both electrodes is divided into several branches. A quantity of simultaneously burning partial spots is determined, first of all, by the instantaneous strength of current of discharge; current densities in the separate spots are constant, with exception of the initial and final conditions, and they will be on the order of 10^5 A/cm^2.

Introduction.

The task of the explanation to the physical essence of electroerosion machining of metal is located in connection with the problem of energy relationships/ratios in the condensed discharge. The complexity of this question will become clear, if one takes into account, which, until now, satisfactorily could not describe even mechanism of the ionization of the discharges of large intensity. There is no doubt, that the main reason for disagreements is the insufficiency of the data about the energy relationships/ratios in the discharge. The only known means of the straight/direct experiment of discharges - Langmuir's probe - here exactly is not applicable, and therefore, at least for the first approximate representation, we are satisfied by the results which gives investigation of potential by nonpolarized probe [1], [2]. In spite of this, to us constantly are not sufficient any information about the separation of current into the ionic and electronic components, without which, is understandable, cannot be concluded about the energy relationships/ratios on the cathode and in the plasma. Consequently, it is necessary to search for the new systematic elements/cells which would contribute to the necessary increase in our knowledge. We discussed the different experimental possibilities and finally they arrived at that conclusion that some hopes gives investigation of a

change in the state of aggregation on the electrodes. In the proposed work we is described the results of some tentative experiments, produced in this direction.

Initial observations concerned the character of the traces of erosion, which appear on the stationary electrodes with the large surface with different geometric proportions of discharger/gap and variable/alternating energy of discharge. Electrodes were always arranged/located according to the relation to each other and they were shielded so that on the electrode being investigated would not operate the jets (flames) of vapors from the opposite electrode. We worked with the low-voltage discharges (to 500 V), ignited of flow of plasma from the auxiliary discharger/gap. It was established/installed, that the discharges with low energy (to 20 J) and with the sufficiently large distances (approximately from 15 mm) leave on the electrode with the large surface several separate partial traces. If this electrode is the anode, then appear the small, but relatively deep, circular craters, rarely scattered throughout the surface. Opposite that the large surface of cathode is damaged at the insignificant depth, but on the large dendritic surfaces.

Page 487.

An increase in the energy, the decrease of the distance between the electrodes and the limitation of their surface area has by consequence merging/coalescence of separate traces, which form the then continuous crater, on which less is noticeable the distinctive character of different polarities. In accordance with its own establishment of older time [3] it was shown that during the condensed discharges on both electrodes appear many spots. With the analogous conclusion/output we are encountered also in the work of Gusev [4], and then in the work of Froome [5], which concerns only cathode spots on mercury. From the fact that the identical discharges form always on the anode more partial traces, than on the cathode, it is possible to conclude that the hot spots do not relate to the independent partial channels, which stretch from the cathode to the anode, but to the branchings, into which is throttled/tapered general/common/total arc discharge near both electrodes. However, from the results evidently, do appear partial spots gradually or, at least some of them, burn simultaneously.

Therefore we tried to then investigate by the trace of time sweep of discharge with the aid of the disk electrode, they rotate with a sufficient speed. Since the formation/education of partial traces in the direction of rotation of disk would introduce into the results considerable uncertainty about their time sequence, the expansion of the arc discharge in this direction was limitedly

insulating partition/baffle with the narrow radial slot. The device/equipment of discharger/gap was again made with applied ignition with the target exclude the actions of vapors from the opposite electrode. Under the middle of slot with the sizes/dimensions 0.6x7.5 mm the disk possessed the linear velocity of 120 m/s.

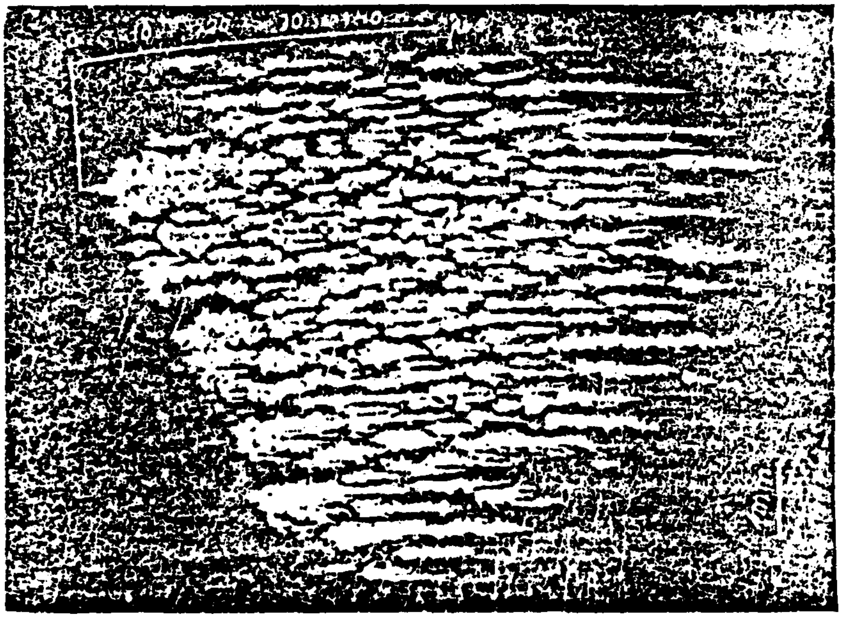

Fig. 1a.

Page 488.

Capacitor discharge with a capacitance of 350 μF and with initial voltage/stress 500 V left on the aluminum disk traces on Fig. 1 (a - cathode, b - anode). Thus the expanded/scanned traces retained the same character as traces at the stationary electrodes with the large surfaces with low energy of discharge and the large distances. While partial anodic traces and on the movable electrode remain circular, the effect of motion on the cathode partial traces is developed by their elongation in the tangential direction. From this it is evident that the cathode spots move over the surface, while anodic they grow

about the motionlessly fastened centers.

Consequently, this experiment again confirms confirmation about the contraction of channel near both electrodes. Then from the photograph it is evident that the total surface, subjected in the specific moment/torque to the action of discharge, on both electrodes it is approximately proportional to the instantaneous value of current, which would testify generally about the constant current density in the spots.

For the exception/elimination of the effect of relative motion of electrodes we produced further investigations on the stationary electrodes during the use/application of optical scanning/sweep. As a result of the fact that photographing spots on the surface of massive el ctrodes strongly hinders by the intense radiation/emission of the space discharge; therefore we used foil electrodes and investigated the process of breakdown from side opposite from the discharge. For recording the formation/education of holes we used chamber/camera from the film rotating by the loop, which with smooth time sweep records only changes in the sizes/dimensions, perpendicular to the direction of motion.

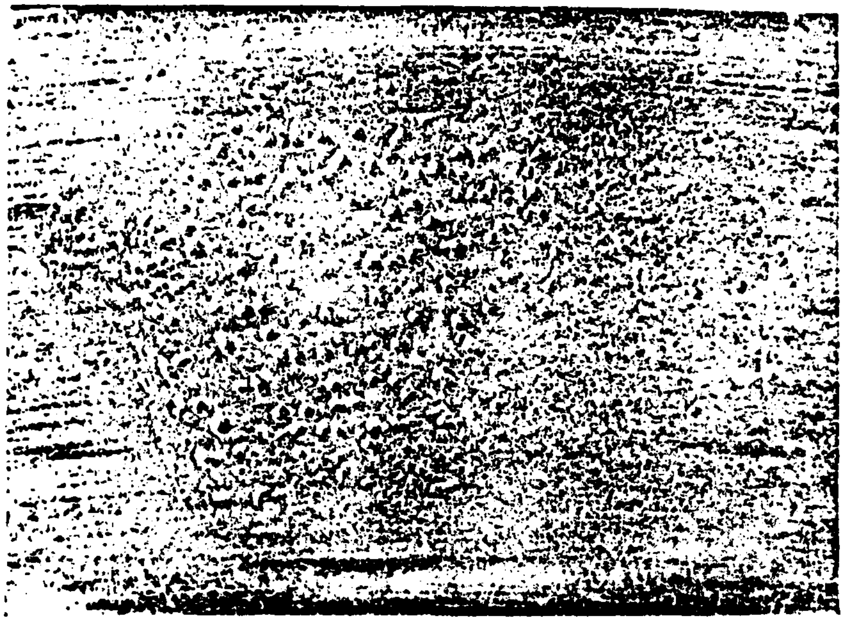

Fig. 1b.

Page 489.

Consequently, it was necessary to undertake further measures which would decrease the increase of hole or the onset of partial spots in the direction of the motion of film. The simplest satisfactory action proved to be the limitation of the surface area of electrode to the value of narrow transverse rectangle by the thin insulating layer. For preventing the gap of foil from the action of the pressures appearing during the discharge, it was stuck on the glass backing/block. The discharger/gap, ignited by spark with advancing from the pulse generator, was arranged as usual, taking into account

the elimination of the effect of the ejection of vapors from the opposite electrode.

Fig. 2 depicts time sweep of the process of breakdown by the anode of aluminum foil with a thickness of 0.01 mm, by discharge with a change in the current in Fig. 2b. If one takes into account, that the existence of partial spot is developed by the intensely radiating trace, then, first of all, we find on the figure the confirmation of previous confirmation about the existence of many short-term partial spots. However, under the specific assumptions we can hence derive some data about the current densities in the spots, since from the photographs sufficiently accurately it is possible to determine sizes/dimensions and quantity of simultaneously burning partial spots. On a change of the current in the partial spot it is possible to assume that it is approximately analogous with a change in the resulting current. In the confirmation of this assumption it is possible to give, first of all, the fact that in the oscillogram of the total current of unnoticeably no gaps which would correspond to ignition and quenching of partial discharges, or that partial currents grow/rise continuously from zero and again continuously they drop to zero. Then it is possible to lean also on the oscillographic establishment with the aid of the plate electrode where the currents of separate plates on their form correspond to the resulting current.

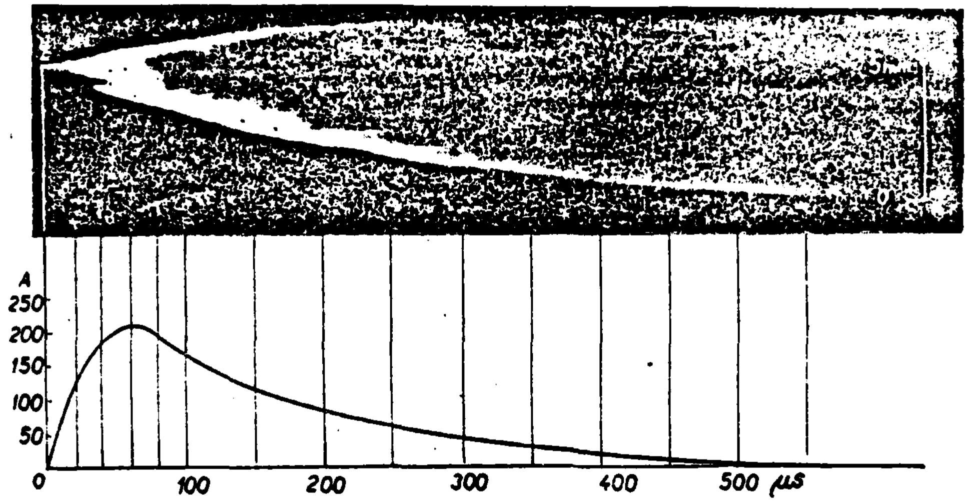

Fig. 2.

Page 490.

Therefore the maximum strength of partial current let us determine as follows: at the specific moment of time simultaneously it burns p partial channels. As a result of the fact that the separate partial spots, as may be seen from the figure, appear very approximately in the identical time intervals, then the maximum strength of partial current will be

$$i_{d\,max} = i_{ct} \frac{i_{c\,max}}{\sum_{1}^{p} i_{cn}};$$

where i_{ct} — maximum value of total current during t, $i_{c\,max}$ — the maximum of total current, and i_{cn} — value of total current at the moment of time $t = n \cdot \tau_c/p$, moreover τ_c — duration of total current. Taking into

account the results, obtained on the rotating electrode, anodic partial spot can be considered circular, so that its surface at the moment of maximum will be $\pi b^2/4$, where b - width electrodes. Current density in the partial spot at the moment of maximum partial current will be then

$$h = \frac{4i_{d\,max}}{\pi b^2}.$$

If we accept in the first approximation, that the partial spot retains this density during entire time of its existence, about which testifies its initial tapered expansion, then thus the found density is real for the entire subjected to the action of the discharge surface at the moment of time t. Certainly, on thus the found values of planes cannot substantially affect some divergences with ignition and quenching of partial spot. Tentative calculation on the basis of given data gave values, which during first 200 μs oscillates in the range of ±15% about the average value $1.65 \cdot 10^5$ A/cm². Somerville and Blevin [6], that are determining current density from the resulting surface of crater in different materials with the square pulses, determined, for duration 1 μs discharge, for the cathode from aluminum the same value $1.6 \cdot 10^5$ A/cm². However, for the more prolonged discharges they give smaller values, for example, with 20 μs already only $4 \cdot 10^4$ A/cm². This contradiction can be explained by the fact that the surface of crater for which these authors determined the density, more than the surface, subjected to the instantaneous action of discharge, that allow/assume even they

themselves.

Concerning the interconnection between a quantity of distant material or the appropriate value of the breakdown of foil and the energy, led to the electrode, it is very complicated problem.

SMOOTH SWEEP.

Until now, we investigated changes in the states of aggregation in electrodes in the losses/depreciations of solid phase. However, it is possible to also investigate phenomena in the flames for data finding about the energy relationships/ratios in the discharge near the surface of electrodes. Utilizing the characteristic property of ejections, that they always occur perpendicular to the surface, subjected to the action of discharge, independent of the form of field, we by the adequate/approaching location of electrodes eliminated the effect of discharge channel on the ejections and on their mutual mixing. The general/common/total experimental device/equipment is schematically marked in Fig. 3.

Page 491.

The electrode E_1 being investigated, which does not intersect and is perpendicular to the opposite electrode E_2, possesses the surface

area, limited by mask/shield II with the circular narrow hole. From image III, obtained auxiliary objective O_1, by slot S is limited the ridge, photographed by the rotating camera, been in the diagram objective O_2, by prism Z by the loop of film F. At the constant velocity of the rotation of chamber/camera v_k the motion of point along the slot with a speed of V_v will be depicted as straight line with inclination/slope v_v/v_k

As a result of the fact that the flames emit up to the considerable distances from the electrode, then it is possible to photograph them directly, without the auxiliary illumination. An example of continuous time sweep of axial sector gives Fig. 4, obtained during the use/application of a tin electrode, equipped with the mask/shield with a diameter of 1 mm during the capacitor discharge 600 μF, charged/loaded to 500 V. The advance of the frontal part of the ejection is developed by the sharp demarcation of shadow and light/world. After this first demarcation are clearly visible also further narrow light strips with the large inclination/slope. Besides these linear traces, obviously corresponding to velocities ejections, at the photographs appears - with the arbitrary polarity of electrodes - the figure, which is characterized by several demarcation who on the whole coincide well with the form of the current of discharge. This figure appears from the continuous recording of the radiation/emission of the flame of unbelted

intensity which is projected/designed with slot for the partition/baffle. The vapors which emerge from the electrode, subjected to the action of discharge, are headed by opening/aperture in the mask/shield and strongly emit directly near the electrode. In proportion to removal/distance from the surface of electrode smoothly decreases the intensity of the radiation/emission of vapors, until at the fixed point it again abruptly increases; this process is repeated several times, of course, with the constantly falling/incident intensity and the definition. Since the same figure on the axial strip give the images of the outflow of gases from the usual opening/aperture, obtained according to Toepler's method. By itself asserts itself thought, that also in our case we deal concerning an analogous change in the pressure. Modulation of the intensity of light and here remains dependent on the pressure, since to pressure it is proportional and the number of excitations which can be considered only radiation source. The fact that here is not manifested the oxidizing action of heat, was proved by the resemblance of the photographs, obtained during the identical discharges in air and in the inert atmosphere. Opposite that, with the decreasing pressure of medium increases the velocity of frontal part and the distance of the surface of a change in the pressure and velocity from the electrodes (developed in our figure by intensity change radiations/emissions), moreover the intensity of the radiation/emission of entire ejection is reduced.

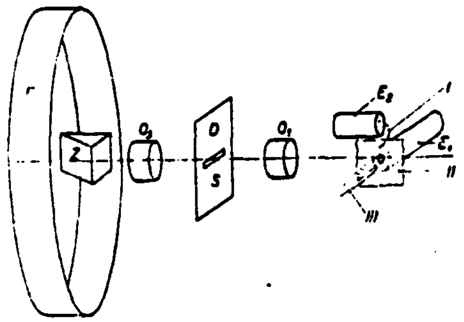

Fig. 3.

Page 492.

When on the way of ejection was placed flat/plane partition/baffle, then near the obstruction shadow figure is made by flat/plane, and compression space between the pressure wave and the obstruction, as are shown to Fig. 5, strongly it emits. Both these of fact confirm the assumed about the dependence of the intensity of radiation/emission on the pressure in the ejection.

By the described method we investigated the dependence of the relationships/ratios of the velocities and pressures in the ejection on some parameters of discharge. First of all we established the influence of the material of electrodes. The remaining conditions of discharge were kept constants: capacitor/condenser 600 μF, initial voltage/stress 500 V, the effective distance between the electrodes 15 mm, the discharge in air, ignition by the anticipating/leading

spark from the pulse generator, the electrode being investigated was covered with mask/shield with the opening/aperture of the diameter of 2 mm.

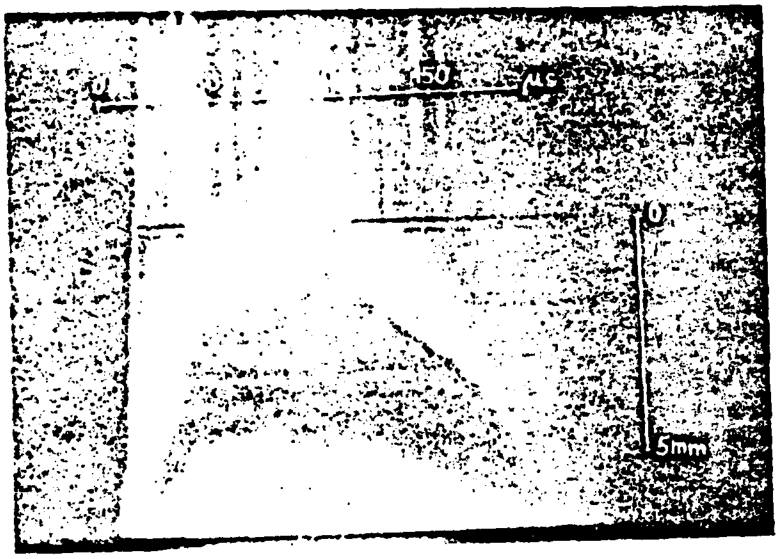

Fig. 4.

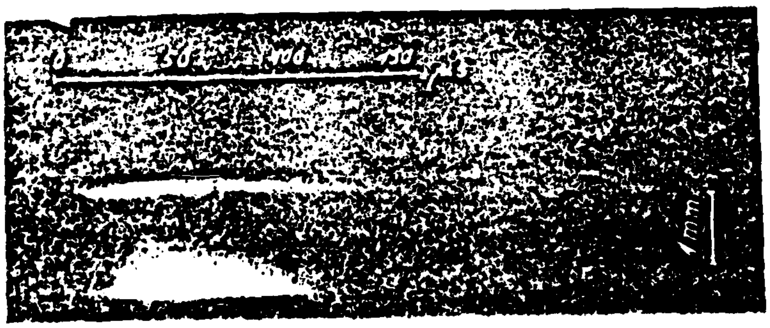

Fig. 5.

Page 493.

The definite on the anode velocities of the frontal part of the ejections were on the order of 10^4 cm/s, while internal velocities were to one order more. The sequence of elements/cells, comprised in the order of the increasing velocities of frontal parts, was

following: Fe, Cu, C, Al, Sn, Zn, Pb, Cd. The largest distance of the surface of a change in the pressure and velocity from the electrodes was found in cadmium, the least - in carbon. In all elements/cells the anodic values are greater than cathode ones. Then was investigated the effect of the diameter of the openings/apertures of mask/shield in carbon electrodes under the same conditions of discharge, as it is earlier. It was established/installed, that the velocity of the frontal part of the flame with the increasing opening/aperture in the mask/shield decreases. The internal velocities with the specific diameter of opening/aperture in the mask/shield during the discharge remain constant/invariable, with exception of the final stage when is developed the specific decrease. With an increase of the diameter of opening/aperture in the mask/shield, beginning from its specific value, is reduced the distance of the surface of pressure shock from the electrodes. This dependence cannot be investigated well, because with the large diameters of openings/apertures boundary becomes unclear, sometimes completely it disappears. Dependence on a change in the supplied power was investigated with the variable capacity and the constant initial voltage/stress 500 V. Measurements were made on the carbon electrode, equipped with mask/shield with a diameter of the opening/aperture of 1 mm. The velocities of frontal parts for the capacitance from 600 to 37.5 μF are placed in Table 1. While with the increasing capacitance the velocity of frontal part is reduced, the

distance of the surface of a change in the pressure from the electrodes grows/rises.

Consequently, we come to the following results: the velocities in the flames depend on the material of electrode, they approximately growing/rising with the decreasing heat of vaporization; the velocities of frontal part increase with the decreasing surface of electrode, subjected to the action of discharge (at the increasing specific power in the spot). The distance of the surface of a change in the pressure from the electrodes is, similarly, the function of the thermal constants of the material of electrodes, specific load on the electrode and the impulse steepnesses. The interconnection of velocities with the heat of vaporization of the material of electrodes can be explained by rate of evaporation. If the specific power in the spot was constant, velocities would be directly proportional to reciprocal values of heat of vaporization. In actuality dependence becomes complicated by the variable quantities both of the current densities in the spot and by a voltage drop across electrodes. The effect of specific load on surface and inclination/slope of impulse/momentum/pulse is obviously established/installed by complicated relationships/ratios with the lateral passage of heat in the dependence on the density of partial spots and during the expansion of partial flames. The distance of the surface of pressure shock from the electrodes is the function of a

number of Mach and section of flame. By these very ones is given its dependence on the values, which are determining the velocities in the flames. Since the diameter of flame is generally proportional to rate of evaporation, the distance of the surface of a change in the pressure from the electrodes is approximately proportional to the instantaneous value of the supplied energy in the case of the constant incidences/drops on the electrodes and to the current of discharge. More precise relationships/ratios we continue to find.

Page 494.

CONCLUSION.

The results of the described experiments can be summed up as follows.

In the condensed discharges the arc of the discharge near both electrodes is divided into several branches. A quantity of in parallel burning partial spots, which constantly appear and which disappear during the discharge, is determined, first of all, by the instantaneous strength of current of discharge. Current densities in the partial spots remain, besides values in initial and finite time, constants during the discharge and are values on the order of 10^5 A/cm^2. The distance of the surface of a change in the pressure from

the electrodes is proportional to a change in the power, led to the electrodes.

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References

[1] Koc S.: Czechosl. Journ. Phys. *3* (1953), 444.
[2] Koc S.: Czechosl. Journ. Phys. *3* (1953), 448.
[3] Hermoch Vl.: Czechosl. Journ. Phys. *4* (1954), 28.
[4] Гусев В. Н.: Анодномеханическая обработка металлов. Москва, 1952.
[5] Froome K. D.: Proc. Phys. Soc. *55* (1948), 424.
[6] Sommerville J. N., Blevin W. R.: Phys. Rev. Ser. II, *15* (1949), 76.

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